



**SMARTSKY**  
NETWORKS®

**Connected Aviation –  
Enabling Innovations  
in the Internet of Things – That Fly**

**National PNT Advisory Board  
Baltimore, MD  
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**Dr. Bruce J. Holmes, VP Digital Aviation**

# Topics

Strategic Context for Aeronautics Innovation

Emerging UAS – UAM – ODM Industries

PNT Dependencies

Operational Threats

PNT Implications to legacy and air mobility innovations

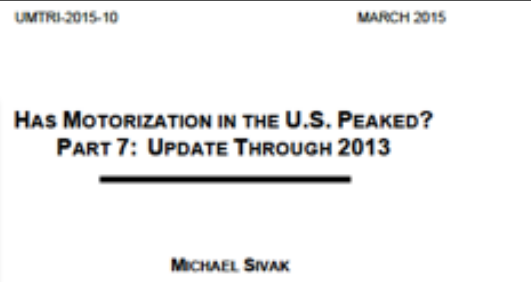
# Strategic Context for Aeronautics Innovation



- Environment
- Airline Consolidation
- Cost of Congestion
- Cost of Infrastructure
- Convergent Solutions



▶ The confluence of emerging technologies affecting aviation, along with innovations in business models, will enable mobility solutions that can transform environmental quality, economic opportunity, accessibility, and travel time, cost, and convenience.



# Strategic Context

## Contextual Observations

- **Productivity:** “We are out of big ideas. (WSJ)” – ODM Is a “big idea” affecting U.S. productivity.
- **Economics:** The safe, productive and efficient mobility of people and goods facilitates economic development and enhanced quality of life. Thus, transportation technologies that respond on-demand to society’s needs for mobility offer broad, transformational opportunities to improve the wellbeing of U.S. citizens through enhanced domestic and international commerce.
- **Airline Consolidation:** In the U.S. and EU, scheduled air carriers are consolidating services toward larger aircraft, serving larger markets, flying longer legs. In the process, a vacuum in smaller community service exists, thereby diminishing economic opportunity and quality of life for increasing numbers of communities.
- **Congestion:** The growth of congestion in large cities and so-called megaregions has vastly outpaced the ability of highways to meet demand. The consequences in lost productivity and congestion-induced carbon emissions create both a challenge and an opportunity for airborne concepts. Ground infrastructure investments are needed, but will not advance mobility as ODM can.
- **Competitiveness:** U.S. economic competitiveness is at high risk due to international ODM

# Aeronautics Innovations and PNT Dependencies

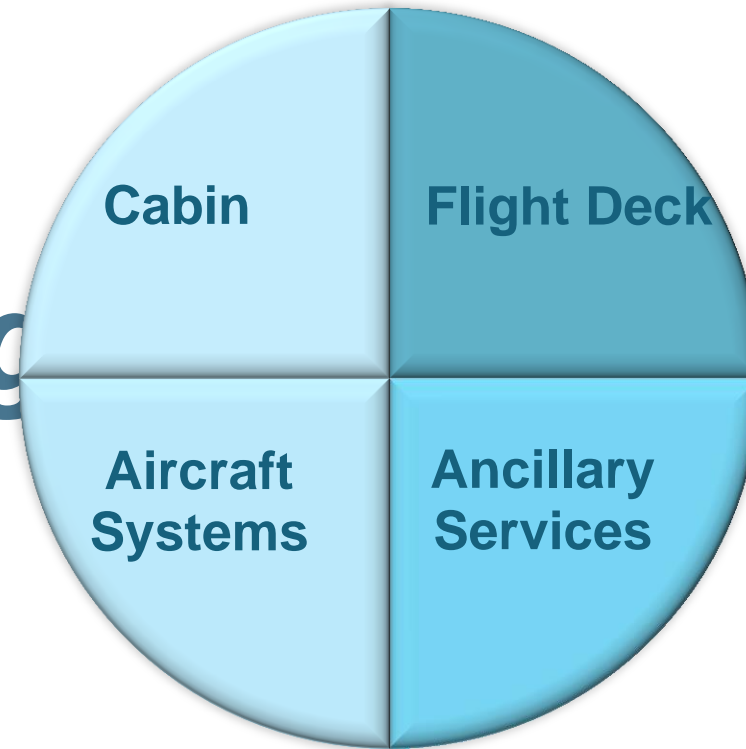
- ▶ PNT is vital in ATG antenna performance (related to beam-forming for interference mitigation, etc.).
- ▶ PNT is vital in ATG network performance (related to minimizing latency and maximizing bandwidth, for example).
- ▶ PNT is vital in Air-to-Air network performance (related to Beyond Visual Line of Sight (BVLOS) for UAS and High Altitude Pseudo-Satellite (HAPS) connectivity capabilities, including V2V deconfliction, for example).
- ▶ PNT is an enabler for the migration from 4G LTE to 5G.

The robustness of growth of this emerging industry depends on PNT resilience, reliability and security

# The Facets of Connectivity Enablement

( = connectivity + open apps & services framework)

*Encompassing*



All components of aviation – aircraft, airspace, airports, and supporting sensors and systems will become connected in the Aviation Internet of Things, enabling continuous replanning with optimization for safety and efficiency.

# Low-Latency Bi-Directional Bandwidth Enablement

Imagine – aviation apps with real-time airborne operations.

**Maintenance Operational Control (MOQA) “SkyData” To Other Aircraft and Ground**

**Flight Safety (FOQA)**

**Electronic Flight Bag**

**Software Upgrades**

**Retail / eCommerce**



**Onboard System Status**

**Powerplant**

**Cybersecurity**

**Flight, Fleet, and Airspace Ops**

What will you do with it?

# UAM – ODM Vision

<http://www.nianet.org/ODM/roadmap.htm>

## ***Vision for On-Demand Mobility (for example):***

***“... air transportation from here to there, anytime, anywhere ...”***

- ▶ Widespread public use of ODM = transformative increases in U.S. productivity.
- ▶ UAM - ODM vehicle and airspace technologies are exportable innovations.
- ▶ The vision must be codified in public policy and strategy to support action by legislators, regulators, innovators, investors, and the public.



<http://cdn.ttgtmedia.com/visuals/German/article/big-data-network-fotolia.jpg>



# Unprecedented Aeronautics Innovation

## Landscape

- ▶ Aakai (H<sub>2</sub> Hybrid eVTOL)
- ▶ Airbus Ventures (Vahana Sky Taxi Project)
- ▶ eHang (eHang-184 Autonomous Aerial Vehicle)
- ▶ Airbus Group (E-Fan Project)
- ▶ Airbus Group (Urban Air Mobility Division)
- ▶ Aeromobil (CTOL Flying Car v3.0)
- ▶ Bell Helicopter, Innovation Division (Urban VTOL Vehicle and ConOps Studies)
- ▶ Boeing (Aurora Flight Sciences)
- ▶ DeLorean Company (VTOL Aircraft, U.S. Patent 9085355)
- ▶ Embry-Riddle electric propulsion consortium (GE, Textron, Hartzell, et. al.)
- ▶ Embraer X
- ▶ E-volo Company (Urban eVTOL)
- ▶ Joby Aviation (Urban eVTOL)
- ▶ KittyHawk Company (Urban eVTOL)
- ▶ Lilium Company (VTOL Jet Aircraft)
- ▶ Pipistrel (Hydrogen-powered Aircraft; Electric VTOL; Regional Commuter)
- ▶ Siemens Corporation (World Record Electric Motors for Aviation)
- ▶ SkyRyse Company (Urban eVTOL)
- ▶ Terrafugia Company (Geely Industries ; TF-X VTOL Flying Car)
- ▶ Uber Elevate (VTOL Urban Transportation Requirements White Paper)
- ▶ Workhorse SureFly (Hybrid VTOL)
- ▶ Zee.Aero (Larry Page Investment – Urban VTOL)
- ▶ Approximately ten other ODM vehicle development projects underway globally, some not yet public
- ▶ Numerous Supplier Organizations (Motors; Fuel Cells; Controllers; Avionics; Composite Material Systems; 3D Printing; etc.)

Globally, > 30 companies investing ODM systems and concepts



Challenges remain: Regulatory; Infrastructure; Consumer and Community Acceptance; Airspace; **PNT**.

# Emerging ODM-UAM-UAS Industries

- ▶ Globally, more than 30 aircraft development projects underway.
- ▶ Urban Air Mobility (e.g., Uber Elevate) - UAM
- ▶ Regional (Thin Haul) On-Demand Mobility
- ▶ Regulatory transformation underway
- ▶ Public value proposition includes vastly increased connectivity among virtually all markets
- ▶ Investments in \$Billions



“The electric flying taxi service that Embraer SA is working on with Uber is “likely” to launch in 2024 or so, the CEO of Embraer Paulo Cesar de Souza has been quoted as saying...

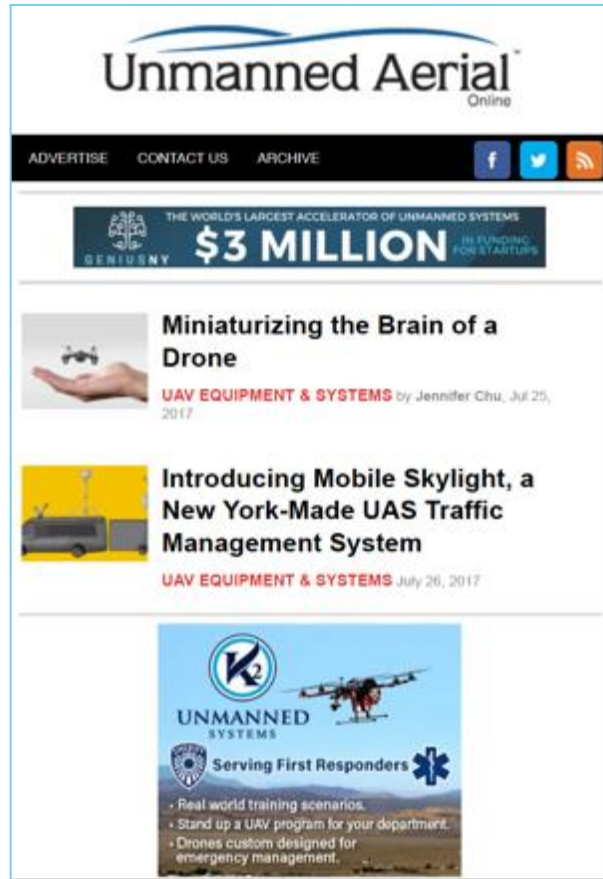


Norway aims for all short-haul flights to be 100% electric by 2040.  
The Guardian.

# Industrial Landscape Framing UAS

With Implications to ODM / UAM Operations

- ▶ The FAA forecasts > 7 million drones in operation with 2.5 million in commercial service by 2020.
- ▶ Industrial developments in the UAS users and airspace management service providers is accelerating.
- ▶ All require resilient, reliable PNT.



NASA plays a significant role in de-risking pre-competitive technologies for the industry and the FAA.

# UAV Operational Threats

- ▶ PNT Denial
  - ▶ Most commercial sUAS cannot operate from 5s to 2 mins without GNSS update to MEMS
  - ▶ PNT denial will almost certainly produce “flyaway” events
  - ▶ PNT will be analogous to Single stream navigation on PART 23 aircraft (general aviation). This could be disastrous to pilotless operations
  - ▶ Most commercial sUAS cannot even takeoff without GNSS
  - ▶ Loss of GNSS would cause loss of geo-fencing
- ▶ Spectrum encroachment
  - ▶ Unintentional or Intentional radiators in GPS L-band would cause significant sporadic harm to ongoing sUAS or ODM operations
- ▶ UAS systems of all sizes absolutely need resiliency and Alternative PNT to successfully complete their mission

# Global Leadership

From the beginning of aviation, the United States has led the Globe in setting regulatory and certification standards, to the significant benefit of U.S. economic competitiveness and balance of trade.

Current international initiatives in emerging UAV-UAM-UAS and ODM technologies, including new vehicle capabilities and architectures, challenge that leadership.

***Protecting, Toughening, and APNT are needed for the US to maintain that leadership!***



*Artist concept of planned Dubai UAM demonstration in 2019*

**Intense**

**Global**

**Acceleration**

# Summary

- ▶ PNT resilience, robustness and security are vital to the emerging sectors, as well as existing Commercial, Business, Regional and General Aviation operations.
- ▶ The new entrants need support in understanding the aeronautical CNS infrastructure risks and dependencies.
- ▶ NASA, the FAA, and DoD can help.

The political, regulatory, policy, and financial domains affecting emerging air mobility concepts are aligning *rapidly* in ways relevant to bold action including **PNT strategies**.

# Thank You!

